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ABSTRACT

This study investigated time in instruction, gain, and rate of learning across three modes of material presentation in a criterion-referenced individualized course of instruction. Two hundred fifty-six college students enrolled in an introductory educational psychology course were randomly assigned to one of three instruction modes of material presentation: a linear programed reading mode without illustrations, a linear programed reading mode with color illustrations, and a paragraph mode which was not in a programed format. Instruction for all modes was individualized in that students worked at their own pace and took unit tests at their own convenience. The results indicated that although criterion could be achieved in the least time in the linear mode, gain and rate were poorest in that mode. The linear mode with illustrations took the most time but showed the best results in terms of gain and rate. These significant differences were most pronounced for readers low in speed and comprehension skills. (WR)

An Analysis of Learning Efficiency By Three Reading Modes in Individualized Instruction

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Abstract

Time in instruction, gain, and rate of learning were examined across three modes of material presentation in a criterion referenced individualized course of instruction. The three modes were a linear programmed reading mode, a linear programmed reading mode with illustrations, and a non programmed paragraph mode. Although criterion could be achieved in the least time in the linear mode, gain and rate were poorest in that mode. The linear mode with illustrations took the most time, but showed the best results in terms of gain and rate. These significant differences were most pronounced for readers low in speed and comprehension skills.

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At present the majority of schools provide successful and rewarding learning experiences for only about one third of their learners. The mastery learning model proposed by Carroll (1963) and Bloom (1968), however, assumes that all, or almost all, of our students are capable of achieving high academic standards. In fact, up to 95% of our students can achieve to high academic levels representative of successful and rewarding learning when instructional and learning procedures specified by the mastery model are employed (Block, 1971)

Carroll's mastery model was based on the theoretical aptitude-time line, where he proposed that the amount of time a student needs to learn a task, under optimal learning conditions, is a function of that student's aptitude for that task. In addition to aptitude, he proposed that time needed to learn is a function of quality of instruction and the student's ability to understand and profit from instruction. If a student is allowed sufficient time needed to learn to some criterion, and he spends the required time, then that student could be expected to achieve the specified level of learning. If enough time is not allowed the student, then the student's degree of learning could be expected to be a function of the ratio of the time actually spent in learning to the time needed. In other words,

$$\text{degree of learning} = f\left(\frac{\text{time spent}}{\text{time needed}}\right)$$

The time actually spent, he argued, is a function of the time allowed and some characteristic of the student's which made him stay at the task, which he called perseverance. Furthermore, since he proposed that the time needed by the

student is a function of that student's aptitude, as well as the quality of instruction and the student's ability to understand that instruction, then the full model could be expressed as,

$$\text{degree of learning} = f\left(\begin{array}{l}\text{1. Time allowed} \quad \text{2. Perseverance} \\ \text{3. Aptitude} \quad \text{4. Quality of Instruction} \\ \text{5. Ability to understand Instruction}\end{array}\right)$$

In 1968 Bloom transformed Carroll's (1963) conceptual model into an effective working model for mastery learning. Bloom proposed that if aptitudes predicted the rate at which a student could be expected to learn a given task, rather than the level of task complexity the student should be able to achieve, as aptitudes were traditionally defined, then one should be able to standardize the degree of learning expected of the student at some mastery level, and systematically manipulate the important instructional variables in Carroll's model, so that all or most students could attain that level. Specifically, if time to learn was left to vary and instruction was good, then all students should be able to master that content.

Experimental studies examining the mastery model support the proposal that aptitudes, as measured by standardized tests or subject-related pretests, are predictive of not only the level to which a student will learn in a given time, but also of the time needed by the student to learn to a given level. The results indicate that, with the exception of certain broad learner aptitudes such as verbal ability, specific aptitudes predict learning rates for specific subjects (Block, 1971, Bloom, 1973; Carroll, 1963a, 1963b; Cronbach et.al., 1969; Camplese et.al., 1973; Dorozinski et. al., 1973; and Sjogren, 1967).

In addition to specific aptitudes and certain general aptitudes which are noted to be good predictors of student success, such as verbal ability, what the mastery model calls "ability to understand instruction" might be expected to have a direct relationship to the student's degree of learning. The experimental findings generally indicate that an instructor can maximize student

learning by modifying the instructional modes in which a subject is presented to fit the student's aptitudes. In other words, if a particular student exhibits poor aptitude for learning in some specific mode of material presentation, then that student might be expected to demonstrate inefficient learning in that mode. According to the mastery model, instruction should be individualized to meet the individual learner's skills if learning is to be efficient (Bloom, 1973; Camplese, et.al., 1973; Cronbach, 1969; Korozinski, et.al., 1973· Kalin, et.al.; 1973; McAvoy, et. al., 1973).

In the mastery model for learning proposed by Carroll (1963) and Bloom (1968), the amount of time spent in instruction, and the amount of gain within a period of time are measures reflecting the student's efficiency of learning. How instructional materials are presented may be manipulated to enhance the student's degree of learning. Therefore, differences in student's time in instruction and amount of gain might be expected under different modes of presentation of instructional materials. In this study, therefore, three different reading modes presenting the same material content have been employed in a criterion-referenced individualized course of instruction in educational psychology. The three instructional modes were a linear programmed reading mode, a linear programmed reading mode with color illustrations, and a paragraph mode which was not in a programmed format. The purpose of the study has been to examine learning efficiency in terms of time spent in instruction, amount of gain from pretest to posttest, and rate, a ratio of gain divided by time, across these three modes of material presentation.

Furthermore, reading skills, taken as a general measure of aptitude as well as an indicant of the student's ability to understand instruction," might be expected to have a direct effect on a student's degree of learning. Reading comprehension, one's ability to understand written material, is a function of a number of subskills, including word recognition, knowledge of word meanings,

sentence and paragraph comprehension, and ability to organize and reproduce what is read (Austin, 1963). Therefore, reading comprehension appears to be a skill which is closely related to what Carroll and Bloom call 'ability to understand,' and it would be expected to influence degree of learning. In addition to comprehension skills, reading speed skills would be expected to influence how quickly a student can progress through instructional materials which are reading oriented. Therefore, individual differences in reading speed and comprehension skills have been examined in relation to time gain, and rate across the three reading modes of instruction.

METHOD:

Two hundred fifty six college sophomore and junior students of both sexes enrolled in an introductory educational psychology course at West Virginia University were employed as subjects for this study. These subjects were randomly assigned to the three instructional modes of material presentation, a linear programmed reading mode without illustrations, a linear programmed reading mode with color illustrations, and a paragraph mode which was not in a programmed format. Instruction for all modes was individualized in that students worked at their own pace and took unit tests at their own convenience. All instruction took place in the open learning center operated by the Educational Psychology Department. Each student worked in an individual carrel except for weekly discussion sessions which were led by the course instructor. Students in each instructional mode recieved the same material content and the same multiple choice achievement tests. A criterion of 90% was established for all students, and each student was allowed as much time as he required to meet that criterion.

Because all instruction took place in the learning center, it was possible to keep an accurate account of the amount of time in minutes each subject spent interacting with instructional materials in an effort to achieve criterion. An

account was also kept for the number of separate occassions on which a student interacted with instructional materials in an attempt to achieve criterion. Furthermore, gain scores from pretests to posttests were collected. Rate of learning efficiency was computed by dividing time in minutes into gain scores. This data were collected for the measurements segment of the course only.

All students involved in the study were administered the Davis Reading Test (1962) at the beginning of the semester. This test was used to stratify subjects into high and low reading speed and reading comprehension groups (plus or minus 1 sd).

RESULTS:

A one way analysis of variance employing the three instructional modes as the independent variable and time in minutes as the dependent variable revealed no significant differences at the .05 level. Furthermore, when time in minutes was examined in a 2 x 3 anova with the three instructional modes and high and low reading comprehension groups (plus or minus 1 sd) as the independent variables, no significant differences were found to exist. However, when Ss were stratified into high and low reading speed groups and were compared across the three experimental treatments in a 2 x 3 anova examining time in minutes, a significant interaction (reading speed x mode) at the .05 level of confidence was revealed (df = 2,82; f = 3.25). This finding suggested that slow readers spent the least amount of time in the linear programmed reading mode ($\bar{X}$ = 17.9) and the most time in the linear programmed mode with illustrations ($\bar{X}$ = 29.1). A Duncan's Multiple Range post test indicated that these mean differences were significant at .05. (df = 82, K. = 6). Although not significantly different, it should also be noted that the fast readers spent the most time in the linear programmed mode ($\bar{X}$ = 22.3), which slow readers completed the quickest. Analysis of covariance, with pretests as the covariate, indicated that the significant

differences were due to the main effects and not differences in S's entry skills.

A one way anova examining the number of separate occassions on which a student interacted with instructional materials in an attempt to achieve criterion across the three instructional modes revealed a significant finding at the .01 level (df = 2, 253; F = 6.4). A Duncan's Multiple Range post test indicated that this significant finding was the result of a significant difference in mean number of trials between mode 1 ($\bar{X}$ = 1.37) and mode 3 ($\bar{X}$ = 1.17) (df = 253, K = 3). This same analysis with student pretests used as a covariate revealed that the significant finding was due to the main effect of modes and not to pretest effects. This finding indicated that all Ss interacted with materials the fewest number of times in the linear programmed reading mode, and the greatest number of times in the paragraph, non programmed mode.

Analysis of trials (number of separate occassions on which Ss interacted with materials) in a 2 x 3 anova with instructional modes and high and low reading comprehension groups as the independent variables revealed a significant difference in instructional modes at the .05 level (df = 2, 82; F = 4.33). No significant differences existed between high and low readers in the analysis, however. A Duncan's Multiple Range post test indicated that the significant F ratio could be explained by the difference between mean trials for mode 1, ($\bar{X}$ = 1.26) the linear mode, and mode 2 ($\bar{X}$ = 1.75) the linear mode with illustrations (df = 82, K = 3). Analysis of covariance revealed that this significant difference held after taking out the variance accounted for by the pretests, the covariate.

A 2 x 3 analysis of variance with instructional modes and high and low reading speed groups as the independent variables and trials to criterion as the dependent variable revealed significant differences between modes at the .05 level (df = 2.82; F = 4.48) and a significant mode x reading speed interaction at the .05 level (df = 2, 82; F = 3.21). A Duncan's Multiple Range post test revealed the significant difference between modes to be accounted for by the difference

in mean trials between mode 1 ($\bar{X}$ = 1.26), the linear mode, and mode 2 ($\bar{X}$ = 1.75), the linear mode with illustrations (df = 82, K = 3). These mean differences held after covarying for pretest effects. Furthermore, the significant interaction effect was revealed by the Duncan's post test to be due to the mean trial differences between slow readers in the linear mode ($\bar{X}$ = 1.24) and slow readers in the linear mode with illustrations ($\bar{X}$ = 2.13) (df = 82, K = 6). No other interaction means were revealed to be significant at the .05 level by the Duncan's test. Therefore, slow readers who spent the least amount of time in minutes in the linear mode and interacted with materials the fewest number of times in that mode, spent the most time in minutes and the most trials in the linear mode with illustrations. Although all kinds of readers spent the least number of trials in the linear programmed mode, the poor readers were observed to spend the most time in the linear mode with illustrations. However, in the one way anova examining trials all Ss were observed to spend the most time in the paragraph mode, which suggests that average readers, which were eliminated from the 2 x 3 anovas, may have accounted for the large number of trials spent in the paragraph mode.

Gain, a measure of posttest score minus pretest score, reflecting achievement, was analyzed in a one way anova across the three instructional modes with no significant finding at the .05 level. However, with gain as the dependent measure in a 2 x 3 anova with high and low reading comprehension groups (plus and minus 1 sd) and the three instructional modes, significant differences at the .05 level were found to exist between modes (df = 2, 82; F = 3.83) and for the reading comprehension x modes interaction effect (df = 2, 82; F = 3.73). In this anova no significant differences between reading comprehension groups existed. A Duncan's Multiple Range Post test indicated that the significant main effect for modes could be accounted for by a significant difference

between the gain means for mode 1 ($\bar{X}$ = 52.19), the linear programmed mode, and mode 2 ($\bar{X}$ = 60.63), the linear programmed mode with illustrations (df = 82; K = 3). That is, gain for the linear mode with illustrations was significantly greater than was gain for the linear mode without illustrations at the .05 level. The Duncan's post test for mean gain differences for the reading comprehension x mode interaction revealed significant differences at the .05 level between the mean for poor readers in the linear programmed mode with illustrations ($\bar{X}$ = 107.14) and the following means: the poor readers in the linear mode without illustrations ($\bar{X}$ = 51.0, K = 6), the good readers in the linear mode without illustrations ($\bar{X}$ = 55.45, K = 5), the good readers in the linear mode with illustrations ($\bar{X}$ = 60.0, K = 4), and the poor readers in the paragraph mode ($\bar{X}$ = 62.63, K = 3) (df = 82). In other words, readers with poor comprehension skills appear to have thrived in terms of gain when they learned in a linear programmed mode of instruction with color illustrations.

Another 2 x 3 anova examining gain across the independent variables of reading speed (high and low) and the three instructional modes revealed significant findings for the main effect of modes (df = 2, 82; F = 3.88) and the interaction effect of modes x reading speed (df = 2, 82; F = 4.25) at the .05 level of confidence. A significant difference for the main effect of reading speed groups was not revealed. The Duncan's Multiple Range post test indicated that the significant main effect for modes could be primarily accounted for by the mean gain differences between mode 1 ($\bar{X}$ = 52.19), the linear mode, and mode 2 ($\bar{X}$ = 60.63), the linear mode with illustrations (df = 82, K = 3), which differed significantly at the .05 level of confidence. The Duncan's test examining mean gain differences among the interaction results revealed that the slow readers in the linear mode with illustrations ($\bar{X}$ = 105.63) achieved significantly better at the .05 level than the following other groups: the slow readers in the linear mode without illustrations ($\bar{X}$ = 49.14, K = 6), the fast readers in the linear mode

with illustrations ($\bar{X}$ = 55.63, K = 5), the fast readers in the linear mode without illustrations ($\bar{X}$ = 50.58, K = 4), and the slow readers in the paragraph mode ($\bar{X}$ = 64.5, K = 3) (df = 82).

Analysis of learning efficiency, expressed as a ratio of gain divided by time, or rate, in a one way analysis of variance across modes revealed a significant F ratio for the main effect at the .05 level (df = 2, 253; F = 3.54). A Duncan's Multiple Range post analysis indicated that learning was most efficient for all students in the linear mode with illustrations ($\bar{X}$ = 4.24), and was significantly poorer ($\bar{X}$ = 4.03)in the linear mode without illustrations ($\bar{X}$ = 2.95) (df = 253, K = 3).

In the 2x3 analyses of variance examining rate across high and low reading comprehension and reading speed groups for the three treatment modes, no significant findings were revealed. This result can be most logically explained by examining the formula for rate, whereby large gains, which were indicated for certain kinds of readers, were cancelled out by similarly large units of time. However, this finding of no differences when readers were stratified does not negate the significant finding for learning efficiency when all readers were included in the one way anova.

DISCUSSION:

This study has examined learning efficiency, expressed as a ratio of gain scores divided by time spent with the learning task, as a function of reading skills and three different reading modes of presentation of instructional materials in an individualized, criterion-referenced educational psychology course. Specifically, attention was given to the dependent variables of time spent in instruction, number of trials to criterion, gain, or amount of achievement from pre to post tests, and rate of learning.

The two hundred fifty six students involved in the study were randomly assigned to three instructional modes of material presentation, a linear programmed reading mode without illustrations, a

programmed reading mode with color illustrations, and a paragraph mode which was not in a programmed format. In accordance with the mastery learning paradigm, a criterion of 90% was established for all students, and time needed by the students to reach criterion was left to vary, as each student paced himself through the instructional materials.

Analysis of variance examining time in minutes needed by students to achieve the 90% criterion revealed no significant differences between instructional modes when all students were used in the anova or when students were stratified into high and low reading comprehension groups. However, a 2 x 3 anova examining time, when readers were stratified into high and low reading speed groups, revealed a significant interaction for the reading speed x mode effect. The Duncan's Multiple Range post test indicated that the slow readers were able to achieve criterion in the least amount of time in the linear programmed reading mode, but that these slow readers spent significantly more time in the linear programmed reading mode with illustrations. An analysis of covariance, with pretests as the covariate, indicated that this significant difference was attributable to the main effects and not differences in student's entry skills.

Analysis of the dependent variable trials to criterion revealed that all subjects interacted with instructional materials the fewest number of times in the linear programmed mode, and the greatest number of times in the paragraph, non-programmed mode. This finding was significant with $\alpha = .01$. Furthermore, when students were stratified by high and low reading comprehension scores, students in the linear programmed mode without illustrations were noted to account for significantly fewer trials to criterion than the students in the linear mode with illustrations. When students were stratifiedby reading speed skills for a similar analysis of trials, the students in the linear mode again were noted to take significantly fewer trials to reach criterion than the students in the linear mode with illustrations. Also, a significant interaction effect was

revealed by this analysis of variance which indicated that slow readers took significantly fewer trials in the linear mode than did slow readers in the linear mode with illustrations. Therefore, slow readers who spent the least amount of time in minutes in the linear mode, and interacted with materials the fewest number of times in that mode, spent the most time in minutes and the most trials in the linear mode with illustrations. In terms of the mastery model, these results appear to indicate that the linear programmed reading mode was quite an efficient instructional mode since criterion could be reached quickest, by even the poor readers, in that mode. However, subsequent analyses of gain and rate suggested that this mode was not as appealing as it first appeared to be.

Gain, reflecting achievement, was analyzed in a one way analysis of variance across the three instructional modes with no significant findings. However, with gain as the dependent measure in a 2 x 3 anova with high and low reading comprehension groups and the three instructional modes as the independent variables, significant differences were found to exist between instructional modes and for the reading comprehension x modes interaction effect. The linear programmed mode with illustrations, which had accounted for the most student time, was noted to account for significantly greater achievement than the linear mode without illustrations, the mode in which students spent the least time. Furthermore, the Duncan's post analysis of the significant interaction effect revealed that the poor readers in the linear mode with illustrations achieved significantly better results than the poor readers in the linear mode without illustrations, the poor readers in the paragraph mode, the good readers in the linear mode with illustrations, and the good readers in the linear mode without illustrations. These significant findings were duplicated when students were stratified by high and low reading speed scores. In other words, the poor readers, in terms of reading comprehension and speed skills, appear to have thrived in terms of

gain in the linear programmed mode with illustrations. Even though they spent the most time in that mode, their time was well invested in terms of achievement.

Learning efficiency, expressed as a ratio of gain divided by time in minutes, or rate, was examined in a one way anova across the three instructional modes for all students. A significant difference between the modes was revealed, which was attributable to learning in the linear mode with illustrations being significantly more efficient for all students than learning in the linear mode without illustrations. Even though the linear mode with illustrations was the one which accounted for the most student investment of time, it was the one which resulted in the best gain, and subsequently rate or efficiency of learning.

When subjects were blocked on reading comprehension and reading speed skills in 2 x 3 analysis of variance testing rate, no significant findings were revealed. This result was attributed to the nature of the rate formula, whereby large gains for certain kinds of readers were cancelled by similarly large units of time.

In terms of Carroll (1963) and Bloom's (1968) model for mastery learning, reading speed aptitude appears to account for more variation in time needed to reach criterion in this study than did specific pretest skills or reading comprehension skills. Although all of the students in this study achieved the 90% criterion, and degree of learning could be said to be constant, measures of gain and rate, or efficiency of learning, have suggested that in order for a student to achieve maximal results and the most efficient learning rate, he must invest sufficient time. That is, the more time the student spent in learning the better his gains and learning rate. The linear programmed reading mode with illustrations appears to have forced students to spend sifficient time to achieve maximal gain and learning rate in this study. Generally speaking, students with high reading aptitude were noted to spend the most time interacting with instructional msterials, and consequently experienced the most gain. Therefore in this study, aptitude held a direct relationship to time, rather than an inverse

relationship which the mastery model might predict. Furthermore, time invested became a relatively accurate predictor of amount of gain.

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